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written before the mantissa, but if negative it must be placed after it? Thus, log .2 is $.3010-1$, log .02 is $.3010-2$, etc. In this way the actual characteristic appears with the logarithm, and labor in computation is somewhat cut down.

If it is required to divide $.3010 - 1$ by 3, change the logarithm to $2.3010 - 3$. The student is made to see that he has an expression of the form $c + m - c'$ in which $c$ and $c'$ may be changed at pleasure, provided their difference remains constant. This leads naturally to the anticipation of another difficulty of the student, which is illustrated by the following problem. It is required to solve the equation, $.2 = .3^x$. The student easily obtains the result

$$x = \frac{\log .2}{\log .3} = \frac{9.3010 - 10}{9.4771 - 10},$$

and is unable to proceed. Perhaps I should say that three quarters of the class subtract the denominator from the numerator while, of the remainder, some know enough not to subtract but do not know what to do. My experience shows the curious fact that if the above result is written $\frac{.3010 - 1}{.4771 - 1}$ many more members of the class will see the correct procedure from this point. Most of the others will handle the fraction correctly if, just before the assignment of this type of problem, the instructor states that, when it is required to multiply or divide by a negative logarithm, the characteristic and mantissa are no longer separated (as always in addition or subtraction) but are combined. So if we wish to add or subtract log .2, we write it $.3010 - 1$, but if we wish to use it as a multiplier or divisor, we combine the parts and write it $-.6990$. This fact is seldom explicitly stated in the books and is such a stumbling block to the student that it seems wise to state it.

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## CORRESPONDENCE.

NOTE. A correspondent asks to be told something about descriptive geometry as a course of more than professional engineering concern. The Editors have asked Professor W. H. ROEVER, of Washington University, to frame a reply to this question, and we print it in full below since we believe it to be of interest to MONTHLY readers in general.

TO THE EDITORS OF THE MONTHLY:

In accordance with your request I submit the following reply to the question of your correspondent:

From my conversations and correspondence with various mathematicians in this country I have been led to the conclusion that many do not have a very clear notion of what descriptive geometry really is. Hence, I will first attempt to state precisely and concisely the nature and object of this branch of applied mathematics.

It is evident that drawing is done in a plane or on a surface. Hence graphical processes are executed in a plane (or on a surface). On the other hand the applied sciences frequently demand a graphical solution for the problems of space of three (and of higher) dimensions. It, therefore, becomes necessary to represent the objects of space by means of figures in a plane and in such a way that the correspondence between the space object and its plane representative is unique and unambiguous, *i. e.*, it must be possible to pass from the space object to the plane representative and also to pass back again from the plane representative to the space object without ambiguity. If, therefore, we can find such plane representatives for the elements (points, lines, planes, etc.) of space, a problem of space is replaced by a problem in the plane. The plane problem may be solvable by graphical methods (*i. e.*, by a process of drawing) and then the solution of this plane problem is the plane representative of the solution of the given space problem. Hence, the space problem is solved by a graphical process.

Now, the object of descriptive geometry is to represent space objects by corresponding plane figures in such a way that the correspondence is unique and unambiguous and also to solve the problems of space by means of the solutions of the corresponding plane problems, the solutions of which are the plane representatives of the solutions of the given space problems.

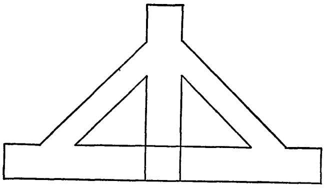
In the remarks made above I have stressed the notion of graphical solutions of space problems. There are many branches of descriptive geometry which serve well this purpose. The most familiar branch is that known as the mongean method. By this method a point of space is represented by two points in the plane which lie on the same perpendicular to a line of the plane (called the ground line). A line of space is represented by two lines in the plane and a plane is represented by two lines which intersect on the ground line. As an example of how this method solves space problems let us consider the simple problem:
To find the line $x$ of space which connects the two points $A$ and $B$ of space.

The point $A$ of space is represented by the two points $A'$, $A''$ of the plane and $B$ is represented by $B'$, $B''$. The line $x'$ which connects $A'$ and $B'$ and the line $x''$ which connects $A''$ and $B''$, together form the pair of lines $(x', x'')$ which represent the solution $x$ of the given space problem. While the mongean method is a good method for the graphical solution of space problems, the plane representatives or pictures which it furnishes do not in general convey to the mind as adequate a notion of the space forms as do some other methods of descriptive geometry. For instance, the mongean representative (consisting of Figs. 1 and 2, page 268) of a certain bracket-shaped object, does not give as clear a notion of the space form of this object as does the picture in Fig. 3.

It thus appears that certain branches of descriptive geometry enable us to make pictures which help to develop the *power of space visualization*, and this power, as every mathematician knows, is a great asset, at least in some branches of mathematics.

An examination of the books on pure and applied mathematics shows clearly that the authors of mathematical works pay very little attention to the proper drawing of figures. Some persons take the point of view that figures are not necessary, but I think every one will admit that if figures are resorted to they should be properly constructed. In order that a figure such as Fig. 3 below may serve to give the dimensions of the object which it represents as well as to convey to the mind an adequate notion of its form, it is essential to know the scales on the three axes $O'X'$, $O'Y'$, $O'Z'$ (which are the representatives of the three mutually perpendicular axes $OX$, $OY$, $OZ$, of space). If the figure is an orthographic projection on the plane of the paper, *either* the directions of the axes $O'X'$, $O'Y'$, $O'Z'$ may be chosen (*i. e.*, the angles $\xi = \sphericalangle Y'O'Z'$, $\eta = \sphericalangle Z'O'X'$, $\zeta = \sphericalangle X'O'Y'$ all greater than 90°), *or* the scales on these axes may be chosen ($l = O'A'$, $m = O'B'$, $n = O'C'$, $l^2 + m^2 > n^2$, $m^2 + n^2 > l^2$, $n^2 + l^2 > m^2$) but not *both*. The question then is, what is the relation between the axes and the scales? A theorem by Schwarz or a theorem by Gauss gives us information concerning this point. If, on the other hand, the projection is parallel and oblique the theorem of Pohlke tells us that both the angles and the scales may be chosen at random.

Fig. 1.



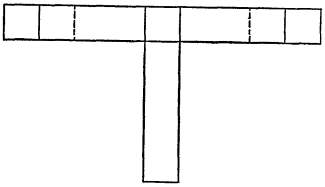


Fig. 2.

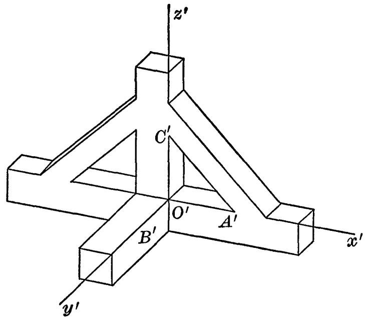


Fig. 3.

I believe that most mathematicians are not familiar with these fundamental theorems or with the fact that most of the representations which they attempt to make are a form of parallel projection known as Cavalier perspective, where $\sphericalangle X'O'Z' = 90°$. How properly to represent in figures of the type of Fig. 3 lines and planes which are perpendicular are also problems with which the average mathematician is not familiar.

Thus, it appears that if we wish adequately to represent and to plot space figures, some knowledge of *axonometry* (that branch of descriptive geometry which enables us to draw figures of the type of Fig. 3) is essential.

Hoping that these remarks will answer your question at least in part, I am

Sincerely yours,

WM. H. ROEVER.

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